Physics 30 Course Review

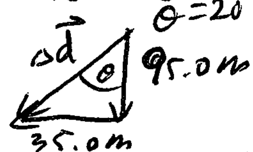
1) A dog chasing a cat runs 140 m south across a field, then 35.0 m west and finally 45.0 m north. The chase takes 2.20 minutes.

   i) Find the distance the dog travels from its starting point. [220 m]

   $\Delta d = 140m + 35.0m + 45.0m = 220 m$

   ii) Find the dog's final displacement from the start; give magnitude and direction. ~~[101 m at 250°]~~

   South: $140m - 45.0m = 95.0m$
   West: $35.0m$

   $\theta = 20°$

   $\Delta\vec{d} = \sqrt{(95.0m)^2 + (35.0m)^2}$

   $\Delta\vec{d} = 101m\ [250°]$

   iii) Find the dog's average speed and average velocity (magnitude and direction). Use m/s for units. [1.67 m/s, 0.765 m/s [250°]]

   $v = \frac{\Delta d}{\Delta t}$ $\quad v = \frac{220m}{132s} = 1.67m/s$

   $2.20min = 132s$

   $\vec{v} = \frac{\Delta\vec{d}}{\Delta t}$

   $\vec{v} = \frac{101m\ [250°]}{132s}$

   $\vec{v} = 0.765 m/s\ [250°]$

2) An automobile of mass 1450 kg accelerates at 1.60 m/s2 when 3.20 x 103 N of force are applied by the wheels to the roadway

   i) What force of friction opposes the car's motion? [880 N]

   $F_f \leftarrow \square \rightarrow F_a$

   $F_{net} = ma$

   $F_f + F_a = ma$

   $F_f = ma - F_a$

   $F_f = 1450\ kg(1.60 m/s^2) - 3.20\times10^3 N$

   $F_f = -880 N$

   $F_f = 880N$ [Against Motion]

   ii) If the automobile accelerates from rest for 8.20 s, find its final speed in km/h. [47.2 km/h]

   $\vec{v}_2 = ?$
   $\Delta t = 8.20s$
   $\vec{a} = 1.60 m/s^2$
   $\vec{v}_1 = 0 m/s$

   $\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$

   $\vec{v}_2 = 1.60m/s^2(8.20s)$

   $\vec{v}_2 = 13.12 m/s$

   $v_2 = 13.12m/s\,(3.6) \Rightarrow 47.2 Km/h$

   iii) What is the kinetic energy of the automobile at this speed? [1.25 x 10^5 J]

   $E_K = \frac{1}{2}mv^2$

   $E_K = \frac{1}{2}(1450Kg)(13.12m/s)^2$

   $E_K = 124797.44J$

   $E_K \approx 1.25\times10^5 J$

iv) How far does the automobile travel during the acceleration? [53.8 m]

$\vec{\Delta d} = ?$

$\Delta \vec{d} = \vec{v_1}\Delta t + \frac{1}{2}\vec{a}\Delta t^2$

$\vec{\Delta d} = \frac{1}{2}(1.60 m/s^2)(8.20 s)^2$

$\vec{\Delta d} = 53.8 m$

v) What work is done by the applied force in accelerating the automobile? [1.72×10^5 J]

$W = F\Delta d$

$W = 3.20 \times 10^3 N(53.8 m)$

$W = 172160 J$

$W \approx 1.72 \times 10^5 J$

3) A vehicle is traveling at 22.0 m/s north. It brakes sharply, reducing its speed by 4.00 m/s every second until it stops.

i) What is the magnitude and direction of the vehicle's acceleration? [4.00 m/s^2 [S]]

$\vec{a} = -4.00 m/s [N] = 4.00 m/s [S]$

ii) How long does the vehicle take to stop? [5.50 s]

↑N

$\Delta t = ?$

$\vec{V_2} = 0 m/s$

$\vec{V_1} = 22.0 m/s$

$\vec{a} = -4.00 m/s^2$

$\vec{V_2} = \vec{V_1} + \vec{a}\Delta t$

$\frac{-\vec{V_1}}{\vec{a}} = \Delta t$

$\vec{\Delta t} = \frac{-22.0 m/s}{-4.00 m/s^2}$

$\vec{\Delta t} = 5.50 s$

iii) How far does the vehicle travel while stopping? [60.5 m]

$\Delta \vec{d} = ?$

$\vec{V_2}^2 = \vec{V_1}^2 + 2\vec{a}\Delta\vec{d}$

$\frac{\vec{V_2}^2 - \vec{V_1}^2}{2\vec{a}} = \Delta\vec{d}$

$\Delta\vec{d} = \frac{-(22.0 m/s)^2}{2(-4.00 m/s)}$

$\Delta\vec{d} = 60.5 m$

$\uparrow y \rightarrow x$

4) A ball is thrown horizontally from the top of a building at a speed of 8.20 m/s. It lands on the ground below 3.60 s later.

i) Find the height of the building. [63.6 m]

$\vec{V}_x = 8.20\,m/s$

$\vec{V}_{1y} = 0\,m/s$

$\vec{a}_y = -9.81\,m/s^2$

$\Delta d_y = ?$

$\Delta t = 3.60\,s$

$\Delta \vec{d}_y = \vec{V}_{1y}\Delta t + \frac{1}{2}\vec{a}_y \Delta t^2$

$\Delta \vec{d}_y = \frac{1}{2}(-9.81\,m/s^2)(3.60\,s)^2$

$\Delta \vec{d}_y = -63.5688\,m$

$\therefore$ Height $\approx 63.6\,m$

ii) Find how far from the base of the building the ball lands. [29.5 m]

$\Delta \vec{d}_x = ?$

$\vec{V}_x = 8.20\,m/s$

$\Delta t = 3.60\,s$

$\Delta \vec{d}_x = \vec{V}_x \Delta t$

$\Delta \vec{d}_x = 8.20\,m/s\,(3.60\,s)$

$\Delta \vec{d}_x = 29.52\,m$

$\Delta \vec{d}_x \approx 29.5\,m$

iii) Find the ball's final vertical velocity just as it reaches the ground. [-35.3 m/s]

$\vec{V}_{y2} = ?$

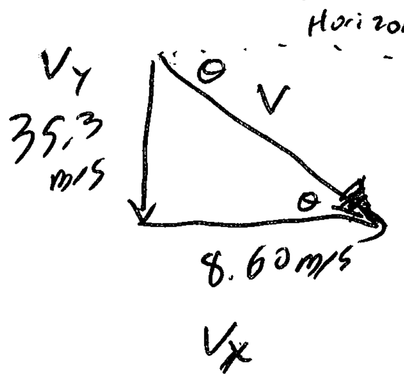
$\vec{V}_{y2} = \vec{V}_{y1} + \vec{a}\Delta t$

$\vec{V}_{y2} = -9.81\,m/s^2(3.60\,s)$

$\vec{V}_{y2} = -35.316\,m/s$

$V_{y2} \approx 35.3\,m/s$ [down]

iv) Find the magnitude and direction ~~(measured from the vertical)~~ of the ball's velocity just as it reaches the ground. (remember that this will be the vector sum of the horizontal and vertical velocities at this point.) [36.3 m/s [-13.1° from horizontal]]



$V = \sqrt{(35.3\,m/s)^2 + (8.60\,m/s)^2}$

$V = 36.33249235\,m/s$

$\theta = \arctan\left(\frac{35.3\,m/s}{8.60\,m/s}\right)$

$\theta = 76.307\ldots^\circ$

$\vec{V} \approx 36.3\,m/s$ [76.3° down from horizontal]

5) On a distant planet, an object thrown vertically upwards from ground level at 6.50 m/s returns to the ground after 1.60 s. What is the acceleration of gravity on this planet? [8.13 m/s^2 [down]]

$a_y = ?$

$v_{y1} = 6.50$ m/s

$\Delta t = 1.60$ s

$\Delta \vec{d} = 0$ m

$\Delta \vec{d} = \vec{v}_1 \Delta t + \frac{1}{2} \vec{a}(\Delta t)^2$

$\frac{-2 v_1 \Delta t}{\Delta t^2} = \vec{a}$

$\frac{-2 v_1}{\Delta t} = \vec{a}$

$\vec{a} = -8.125$ m/s^2

$\vec{a} \approx 8.13$ m/s [down]

6) A student lifts 60 packages of laundry detergent from a pallet on the floor to a display shelf 1.20 m above the floor. Each package has a mass of 4.20 kg; the job takes 8.20 minutes.

i) How much work does the student do in total? [2.97 kJ]

Weight = mg

= 4.20 kg (−9.81 m/s^2)

= −41.202 N

$W = Fd\cos\theta$

$W = 41.202$ N (1.20 m) cos 0°

$W = 49.4424$ J

60 Packages ⇒ $W = 49.4424$ J (60)

$W = 2966.544$ J

$W \approx 2.97$ kJ

ii) How much power does he develop? [6.03 W]

$P = \frac{W}{\Delta t}$

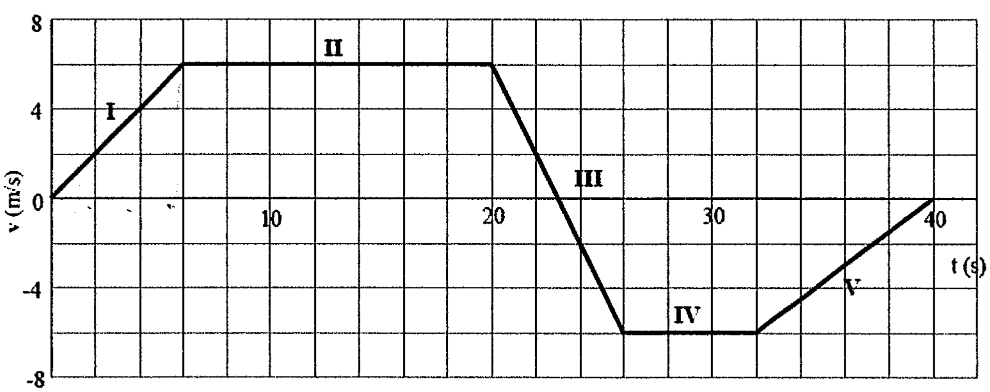
8.20 min = 492 s

$P = \frac{2966.544 \text{ J}}{492 \text{ s}}$

$P = 6.0295609756$ W

$P \approx 6.03$ W

7) The graph shows the motion of a cyclist along a north-south roadway. Use the graph to answer the questions.



i) Describe the cyclist's motion in each of sections I - V.

I: Increasing speed North

II: constant speed North

III: Accelerating South

IV: constant speed South

V: Slowing down to a stop – accelerating north

ii) Find the maximum acceleration of the cyclist. [-2.0 m/s²]

Section III: $\vec{a}$ = Slope: $\frac{-6.0\,m/s - 6.0\,m/s}{26\,s - 20\,s}$

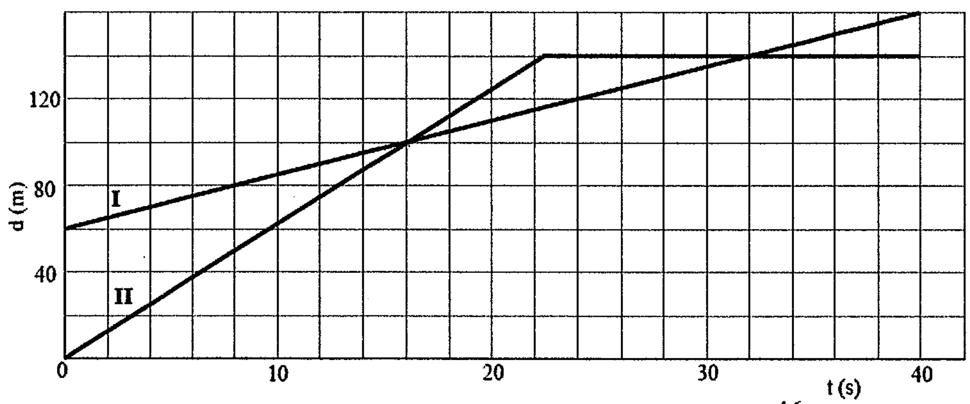
$\vec{a} = -2.0\,m/s^2$

iii) How far does the cyclist travel during the first 20 s? [120 m] 102 m

Area under the curve: $\frac{6\,s(6\,m/s)}{2} + 6\,m/s(14\,s)$

$\Delta\vec{d} = 102\,m$

8) Use the position-time graph to answer the questions about objects I and II.



i) What is the initial velocity of each object? [[I: 2.5 m/s, II: 6.4 m/s]

Slope:

I: $\frac{160\,m - 60\,m}{40\,s}$ $V_I = 2.5\,m/s$

II: $\frac{140\,m - 0\,m}{22\,s}$ $V_{II} = 6.4\,m/s$

ii) If the motion shown is along a north-south line with north positive and point X as a reference, where is each object initially? [I: At X II: 60 m [S]]

If I is at point x, then II is 60 m [S]

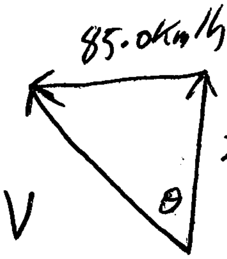
iii) At what time does object II overtake object I? [16 s]

16 s

iv) When are the two objects again in the same position? Explain how this occurred. [32 s]

32 s Object II stops and object I overtakes it.

9) A pilot heads her plane due north; her plane's speed in still air is 245 km/h. What is the velocity (magnitude and direction) of the plane relative to the ground if there is a wind from the east at 85.0 km/h? [259 km/h [109°]]



$V = \sqrt{(245\ Km/h)^2 + (85.0\ Km/h)^2}$

$V = 259.3260496\ Km/h$

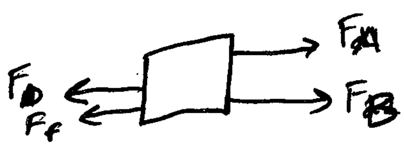
$\theta = \arctan\left(\frac{85.0\ Km/h}{245\ Km/h}\right)$

$\theta = 19°$

$\vec{V} \approx 259\ Km/h$ [N19°W]

or **259 Km/h [109°]**

10) Two dogs, A and B, are pulling a sled across a horizontal, snowy surface. Dog A exerts a force of 200 N [forward] and dog B a force of 150 N [forward]. The force of friction exerted by the snow on the sled is 60 N [backward]. The driver attempts to slow down the sled by pulling on it with a force of 100 N [backward]. Starting with a free-body diagram, calculate the net force on the sled. [190 N [forward]]



$F_A = 200N$

$F_B = 150N$

$F_D = -100N$

$F_f = -60N$

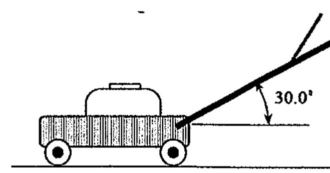
$F_{NET} = F_A + F_B + F_D + F_f$

$F_{NET} = 200N + 150N + (-100N) + (-60N)$

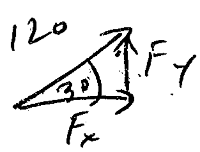
$F_{NET} = 190\ N$

F_{NET} = 190N [Forward]

11) A man exerts a force of 120 N along the handle of the lawnmower shown to the right. He moves the lawnmower at a constant speed a distance of 22.0 m in 28.0 s.



i) How much force does the man exert vertically downward? [60.0 N]

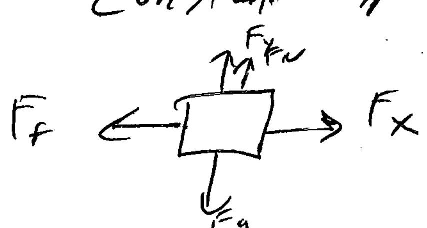


$F_Y = 120 \sin 30°$

$F_Y = 60.0N$

ii) What is the force of friction acting against the motion? [104 N]

constant speed ∴ $F_{net} = 0$



$F_{Net\,x} = F_f + F_x = 0$

$F_f = -F_x$

$F_x = 120 \cos 30°$

$\therefore F_f = -120N \cos 30°$

$F_f = -103.9230485\ N$

$F_f \approx$ **104N [Left]**

iii) How much work does the man do in moving the mower? [2.29 kJ]

$W = Fd \cos\theta$

$W = 120N(22.0m)(\cos 30°)$

$W \approx 2286.31\ J$

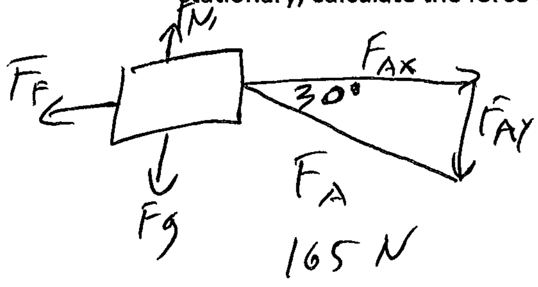
$W \approx 2.29\ KJ$

iv) What power does he develop? [81.7 W]

$P = \frac{W}{T}$ $\quad P = \frac{2286.31\,J}{28.0\,s}$ $\quad P = 81.65392857\,W$

$P \approx 81.7\,W$

12) The magnitude of the applied force on a desk is 165 N and 30.0° below the horizontal. If the desk remains stationary, calculate the force of static friction acting on the desk. [143 N [180°]]



Not moving $\therefore F_{NET} = 0$ $\quad F_{AX} = 165\,N\cos 30°$

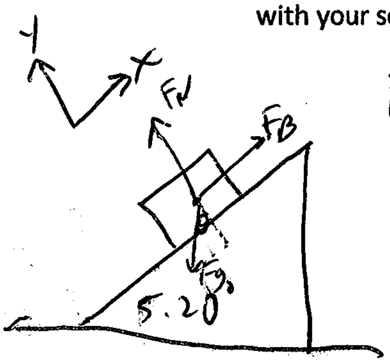
$\therefore F_{Net\,x} = F_f + F_{AX} = 0$

$F_f = -F_{AX}$ $\quad F_f = -142.8941916\,N$

$F_f = -165\,N\cos 30°$ $\quad F_f \approx 143\,N\,[180°]$

13) A 1250 kg automobile is parked on a driveway inclined at 5.20° to the horizontal. The car is positioned a distance of 12.0 m above the base of the driveway, which connects to a horizontal roadway.

i) Find the force exerted by the car's brakes to maintain it in position; include a free-body diagram with your solution. [1.11 kN]



$F_{Net\,x} = \vec{F}_B + \vec{F}_{gx} = 0$

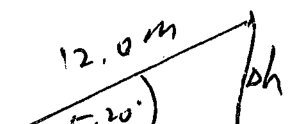
$\vec{F}_B = -\vec{F}_{gx}$

$\vec{F}_B = -(-9.81\,m/s^2)(1250\,kg)(\sin 5.20°)$

$F_B = 1111.382015\,N$

$F_B \approx 1.11\,kN$ [away from base]

ii) Find the car's gravitational potential energy in this position. [13.3 kJ]



$\Delta h = 12.0\,m \sin 5.20°$

$E_p = mg\Delta h = 1250\,kg\,(9.81\,m/s^2)(12.0\,m \sin 5.20°)$

$E_p = 13336.58418\,J \approx 13.3\,kJ$

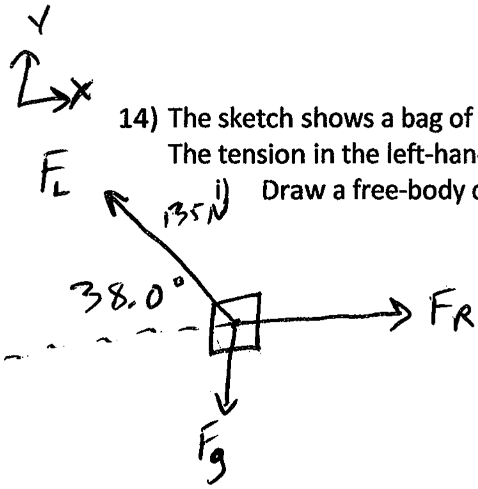
iii) If the brakes are released, find the speed with which the car reaches the roadway, if this is a conservative system. [4.62 m/s]

$E_p = E_p'$ $\quad v = \sqrt{2g\Delta h}$ $\quad v \approx 4.62\,m/s$

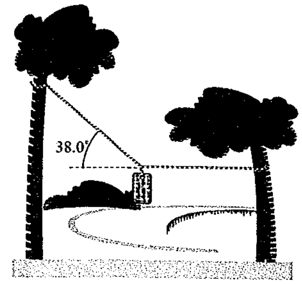
$mg\Delta h = \frac{1}{2}mv^2$ $\quad v = \sqrt{2(9.81)(12.0\,m)(\sin 5.20°)}$

$g\Delta h = \frac{1}{2}v^2$

$2g\Delta h = v^2$ $\quad v = 4.61936182\,m/s$



14) The sketch shows a bag of food suspended between two trees from two ropes. The tension in the left-hand rope 135 N.



i) Draw a free-body diagram of the ropes and food bag.

ii) Find the weight of the food bag. [83.1 N]

$\vec{F}_{NETY} = \vec{F}_{Ly} + \vec{F}_g = 0$

$\vec{F}_g = -\vec{F}_{Ly}$

$\vec{F}_g = -135\,N(\sin 38°)$

$\vec{F}_g = -83.11429917\ N$

$\vec{F}_g \approx 83.1\ N$ [down]

iii) Find the tension in the right-hand rope. [106 N]

$F_{NETX} = \vec{F}_{Lx} + \vec{F}_R = 0$

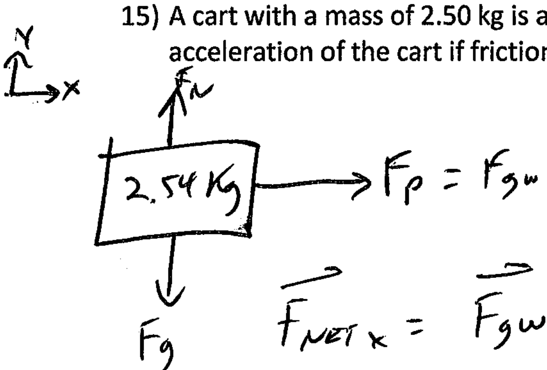
$\vec{F}_R = -\vec{F}_{Lx}$

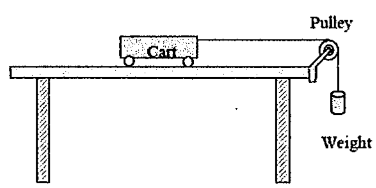
$\vec{F}_R = -[-135\ N(\cos 38°)]$

$\vec{F}_R = 106.3814517\,N$

$\vec{F}_R \approx 106\,N$ [Right]

15) A cart with a mass of 2.50 kg is accelerated by a weight as shown. The weight has a mass of 40.0 g. Find the acceleration of the cart if friction is neglected. [0.154 m/s^2 [Towards Pulley]]





$\vec{F}_{NET\,x} = \vec{F}_{gw} = m\vec{a}$

$\vec{F}_{gw} = m_T\vec{a}$

$m_w\vec{g} = m_T\vec{a}$

$\vec{a} = \frac{m_w\vec{g}}{m_T}$

$\vec{a} = \frac{0.04\,Kg(9.81\,m/s^2)}{2.54\,Kg}$

$\vec{a} = 0.1544881\,m/s^2$

$\vec{a} \simeq 0.154\ m/s^2$ [towards Pulley]

16) Two men prepare to slide a wooden box containing a table saw through a displacement of 15.0 m east across the horizontal floor of a warehouse. The box with saw has a mass of 145 kg. The static friction coefficient between the box and the floor is 0.550; the kinetic friction coefficient is 0.300.

i) What force is needed to just move the box? [782 N]

$\mu_s = 0.550$

$F_{fs} = ?$

$F_N = -F_g = mg$

$F_A = ?$

$F_{fs} = \mu_s F_N$

$F_{fs} = \mu_s mg$

$F_{fs} = 0.550(145\,Kg)(9.81\,m/s^2)$

$F_{fs} = 782.3475\ N$ [W]

$F_A = -F_{fs}$

$\therefore F_A \simeq 782\,N$ [E]

ii) Once the box is moving, what force is needed to keep it moving at a constant speed? [427 N]

$\mu_K = 0.300$
$F_{FK} = ?$
$F_A = ?$
$F_N = -F_g = mg$

$F_{FK} = \mu_K F_N$
$F_{FK} = \mu_K mg$
$F_{FK} = 0.300(145 kg)(9.81 m/s^2)$

$F_{FK} = 426.735 N$
$\therefore F_A \approx 427 N [E]$

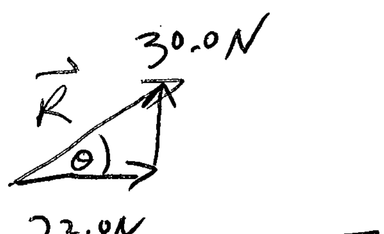
iii) The men are able to apply a maximum horizontal force of 850 N to the box. Describe the motion of the box (including numbers) if this force is applied. [~~a = 0.467 m/s²~~] $\vec{a} = 2.92 m/s^2 [E]$

$F_A = 850 N [E]$
$F_{FK} = 427 N [W]$
$\vec{a} = ?$

$\vec{F}_{net} = m\vec{a}$
$\vec{F}_A + F_{FK} = m\vec{a}$
$\frac{F_A + F_{FK}}{m} = \vec{a}$

$\vec{a} = \frac{850 N - 427 N}{145 kg}$
$\vec{a} = 2.91724 m/s^2$
$\vec{a} \approx 2.92 m/s^2 [E]$

17) Find the resultant (magnitude and direction) of the addition of the two horizontal forces below. Include a vector sketch.
22.0 N at 0.00° and 30.0 N at 90.0° [37.2 N [53.7°]]



$\theta = \arctan\left(\frac{30.0 N}{22.0 N}\right)$
$\theta = 53.7461226°$

$\vec{R} = \sqrt{(22.0 N)^2 + (30.0 N)^2}$
$\vec{R} = 37.2021548 N$

$\vec{R} = 37.2 N [53.7°]$

18) A car traveling south at a constant speed rounds a left-hand curve in the roadway that has a radius of 210 m; the car travels at a constant speed of 18.0 m/s and has a mass of 910 kg.

i) What is the centripetal acceleration of the car? [1.54 m/s²[Towards Centre]]

$a_c = ?$
$r = 210 m$
$v = 18.0 m/s$
$m = 910 kg$

~~$\vec{F}_c = m\vec{a}$~~
$\vec{a}_c = \frac{v^2}{r}$
$\vec{F}_c = $ ~~910 kg~~ $\left(\frac{(18.0 m/s)^2}{210 m}\right)$
~~$F_c = 1404 N$~~

$a_c = 1.542857 m/s^2$
$a_c \approx 1.54 m/s^2$ [Towards Centre]

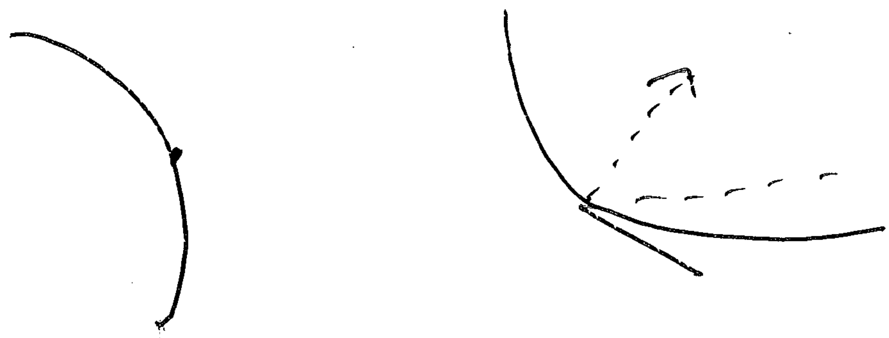
ii) What frictional force is needed between the car's tires and roadway to keep the car on the road? [1.40 kN [Towards Centre]]

$F_f = F_c$

$F_f = m\frac{v^2}{r}$
$\vec{F}_f = 910 kg\left(\frac{(18.0 m/s)^2}{210 m}\right)$
$\vec{F}_f = 1404 N$

$F_f \approx 1.40 kN$ [towards centre]

iii) As the car reaches the midpoint of the curve, its instantaneous velocity direction is 291°. What is the direction of its acceleration at this instant? [21.0°]



$291° + 90° = 381°$
$- 360°$
$21°$

19) A medical centrifuge exerts 920 g's (multiples of the force of gravity) on sample tubes when it is rotating at 41 times each second. What is the radius of the curved path followed by the sample tubes? [13.6 cm]

$r = ?$
$f = 41\ Hz$
$\vec{a} = 920g$

$\vec{a} = 4\pi^2 r f^2$

$\frac{\vec{a}}{4\pi^2 f^2} = r$

$r = \frac{920 (9.81\ m/s^2)}{4\pi^2 (41\ Hz)^2}$

$r = 0.135997017 6\ m$

$r \approx 0.136\ m \approx 13.6\ cm$

20) Two people, A and B, are sitting on a bench 0.60 m apart. Person A has a mass of 55 kg and person B a mass of 80 kg. Calculate the magnitude of the gravitational force exerted by B on A. (8.2×10^{-7} N)

$M_a = 55\ Kg$
$M_b = 80\ Kg$
$r = 0.60m$
$G = 6.67 \times 10^{-11}...$
$F_g = ?$

$\vec{F_g} = \frac{G\ m_a m_b}{\vec{r}^2}$

$\vec{F_g} = \frac{6.67 \times 10^{-11} (55\ Kg)(80\ Kg)}{(0.60m)^2}$

$\vec{F_g} = 8.152222 \times 10^{-7}\ N$

$\vec{F_g} = 8.2 \times 10^{-7}\ N$ [Towards B]

21) Two identical oil tankers are moored at a distance of 140 m from each other. A force of gravitational attraction of 1.52 x 10-2 N exists between the tankers.

i) What is the mass of each tanker? (HINT: let the masses be m1 = m2 = m.) [2.11×10^6 kg]

$m_1 = m_2 = m$
$F_g = 1.52 \times 10^{-2}\ N$
$r = 140\ m$

$F_g = \frac{G m_1 m_2}{r^2}$

$F_g = \frac{G m^2}{r^2}$

$\pm\sqrt{\frac{F_g r^2}{G}} = m$

$m = \sqrt{\frac{1.52 \times 10^{-2} N (140 m)^2}{6.67 \times 10^{-11}}}$

$m = 2113425.352\ Kg$

$m \approx 2.11 \times 10^6\ Kg$

ii) If friction is neglected and the mooring of one tanker is released, find its acceleration towards the second tanker. [7.19×10^{-9} m/s^2]

$F = m\vec{a}$

$\frac{F}{m} = \vec{a}$

$\frac{1.52 \times 10^{-2} N}{2113425.352 kg}$

$7.192115865 \times 10^{-9} m/s^2 = \vec{a}$

$\vec{a} \simeq 7.19 \times 10^{-9} m/s^2$ [towards second tanker]

22) The combined mass of a bobsled and two riders is 390 kg. The sled-rider system has a constant momentum of 4.68×10^3 kgm/s [W]. Calculate the velocity of the sled. [12.0 m/s [W]]

$m = 390 kg$

$\vec{p} = 4.68 \times 10^3 kg\ m/s [W]$

$\vec{v} = ?$

$\vec{p} = m\vec{v}$

$\frac{\vec{p}}{m} = \vec{v}$

$\vec{v} = \frac{4.68 \times 10^3 kg [W]}{390 kg}$

$\vec{v} = 12.0 m/s [W]$

23) To improve the safety of motorists, modern cars are built so the front end crumples upon impact. A 1200-kg car is travelling at a constant velocity of 8.0 m/s [E]. It hits an immovable wall and comes to a complete stop in 0.25 s.

→ East

i) Calculate the impulse provided to the car. [9.6×10^3 Ns [W]]

$\vec{J} = m\Delta\vec{v}$

$\vec{J} = 1200 kg (0 m/s - 8.0 m/s)$

$\vec{J} = -9600 Ns$

$\vec{J} \simeq 9.6 \times 10^3 Ns [W]$

ii) What is the average net force exerted on the car? [3.8×10^4 N [W]]

$\vec{F}\Delta t = m\Delta\vec{v}$

$\vec{F} = \frac{m\Delta\vec{v}}{\Delta t}$

$\vec{F} = \frac{1200 kg (0 - 8.0 m/s)}{0.25 s}$

$\vec{F} = -38400 N$

$\vec{F} \simeq 3.8 \times 10^4 N [W]$

24) A 75-kg hunter in a stationary kayak throws a 0.72-kg harpoon at 12 m/s [right]. The mass of the kayak is 10.0 kg. What will be the velocity of the kayak and hunter immediately after the harpoon is released? [0.10 m/s [left]]

→ Right

$p = p'$

~~$p_{HK} + p_H$~~ $= p_{HK}' + p_H'$

$p_{HK}' = -p_H'$

$m_{HK} V_{HK}' = -m_H V_H'$

$V_{HK}' = -\frac{m_H V_H'}{m_{HK}}$

$V_{HK}' = -\frac{(0.72 kg)(12 m/s)}{(75 kg + 10.0 kg)}$

$V_{HK}' = -0.101647058 m/s$

$V_{HK}' \simeq 0.10 m/s$ [left]

25) The maximum force needed to draw a child's bow is 150 N; the bowstring is drawn back through a distance of 0.350 m.

i) What is the spring constant for the bow? [429 N/m]

$F = -kx$

$-\frac{F}{x} = k$

$k = \frac{150 N}{0.350 m}$

$k = 428.571428 N/m$

$k \approx 429 N/m$

ii) How much potential energy is stored in the drawn bow? [26.3 J]

$E_p = \frac{1}{2} k \Delta x^2$

$E_p = \frac{1}{2}(429 N/m)(0.350 m)^2$

$E_p = 26.27625 J$

$E_p \approx 26.3 J$

iii) If the bow is used to shoot an arrow with a mass of 85.0 g, find the speed with which the arrow leaves the bow. [24.9 m/s]

$E = E'$

$E_p = E_K$

$\frac{1}{2} k \Delta x^2 = \frac{1}{2} m v^2$

$\pm\sqrt{\frac{k \Delta x^2}{m}} = v$

$v = \sqrt{\frac{429 N/m (0.350 m)^2}{0.085 kg}}$

$v = 24.86492924 m/s$

$v \approx 24.9 m/s$

iv) The bow is used to fire the arrow straight upwards. If 3.00 J of energy are lost through air resistance as the arrow rises, how high does it go? [27.9 m]

$E_p - 3.00 J = E'$

$\frac{1}{2} k \Delta x^2 - 3.00 J = mg\Delta h$

$\Delta h = \frac{\frac{1}{2} k \Delta x^2 - 3.00 J}{mg}$

$\Delta h = \frac{\frac{1}{2}(429 N/m)(0.350 m)^2 - 3.00 J}{0.085 kg (9.81 m/s^2)}$

$\Delta h = 27.9141932 m$

$\Delta h \approx 27.9 m$

26) A rock with a mass of 3.40 kg falls from rest from the top of an ocean cliff. During the fall to the water, 45.0% of the rock's initial gravitational potential energy is lost due to air resistance. If the cliff is 110 m high, how fast should the rock be moving as it hits the water? [34.5 m/s]

$0.55 E = E'$

$0.55 (mgh) = \frac{1}{2} m v^2$

$1.1 gh = v^2$

$\pm\sqrt{1.1 gh} = v$

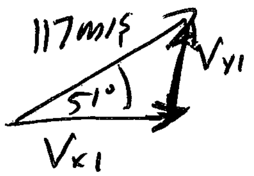
$v = \pm\sqrt{1.1 (9.81 m/s^2)(110 m)}$

$v = \pm 34.4530148 m/s$

$v \approx 34.5 m/s$ [down]

27) A trebuchet fires a projectile at an angle of 51° with a speed of 117 m/s. Find

i) The time the projectile is in the air if it is fired on level ground. [18.6 s]



$\Delta \vec{d}_y = 0\,m$

$\vec{V}_{y1} = 117\,m/s \sin 51°$

$\Delta t = ?$

$\vec{a} = -9.81\,m/s^2$

$\Delta \vec{d}_y = \vec{V}_{y1}\Delta t + \frac{1}{2}\vec{a}(\Delta t)^2$

$-V_{y1}\Delta t = \frac{1}{2}\vec{a}(\Delta t)^2$

$\frac{-2V_{y1}}{\vec{a}} = \Delta t$

$\Delta t = \frac{-2(117\,m/s \sin 51°)}{-9.81\,m/s^2}$

$\Delta t = 18.5374266\,s$

$\Delta t \simeq 18.6\,s$

ii) The horizontal distance it covers. [1370 m]

$\Delta \vec{d}_x ?$

$\vec{V}_x = 117\,m/s \cos 51°$

$\Delta t = 18.5374266\,s$

$\Delta d_x = V_x \Delta t$

$\Delta d_x = 117\,m/s \cos 51° (18.5374266\,s)$

$\Delta d_x = 1364.919725\,m$

$\Delta d_x \simeq 1360\,m$

iii) The maximum height reached. [421 m]

$\vec{V}_{y1} = 117\,m/s \sin 51°$

$\vec{V}_{y2} = 0\,m/s$

$g = -9.81\,m/s^2$

$\Delta d = ?$

$\vec{V}_{2y}^2 = \vec{V}_{1y}^2 + 2\vec{a}_y \Delta \vec{d}_y$

$\frac{-\vec{V}_{1y}^2}{2\vec{a}_y} = \Delta \vec{d}_y$

$\Delta \vec{d}_y = \frac{-(117\,m/s \sin 51°)^2}{-9.81\,m/s^2}$

$\Delta \vec{d}_y = 421.383872\,m$

$\Delta d_y \simeq 421\,m$

28) A net force of 34 N [forward] acts on a curling stone causing it to accelerate at 1.8 m/s2 [forward] on a frictionless icy surface. Calculate the mass of the curling stone. [19 kg]

$\vec{F} = m\vec{a}$

$\frac{\vec{F}}{\vec{a}} = m$

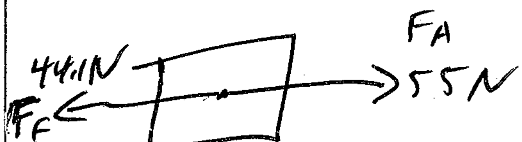
$m = \frac{34\,N}{1.8\,m/s^2}$

$m = 18.888888\,kg$

$m \simeq 19\,kg$

29) A 20kg and a 10kg block of identical material are connected by a light rope on a level surface. An applied force of 55 N [right] causes the blocks to accelerate. While in motion, the magnitude of the force of friction on the block system is 44.1 N. Calculate the acceleration of the blocks. [0.36 m/s² [right]]

→ Right



$F_{Net} = m\vec{a}$

$F_A + F_F = (M_1 + M_2)\vec{a}$

$\frac{F_A + F_F}{M_1 + M_2} = \vec{a}$

$\vec{a} = \frac{55N - 44.1N}{20kg + 10kg}$

$\vec{a} = 0.363333\,m/s^2$

$\vec{a} \simeq 0.36\,m/s^2$ [right]

30) An elevator and its occupants have a mass of 1300 kg. The elevator motor lifts the elevator to the 12th floor, a distance of 40.0 m, in 75.0 s.

i) What is the power output of the elevator? [6.80×10^3 W]

$P = \frac{W}{\Delta t}$

$P = \frac{F \Delta d \cos\theta}{\Delta t}$

$P = \frac{mg \Delta d \cos\theta}{\Delta t}$

$P = \frac{1300\,kg\,(40.0\,m)(9.81\,m/s^2)\cos 0^\circ}{75.0\,s}$

$P = 6801.6\,W$

$P \approx 6.80 \times 10^3\,W$

ii) What is the efficiency of the system if the motor must generate 9.40 kW of power to do the specified work? [0.724]

$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{6801.6\,W}{9.40 \times 10^3\,W} \approx 0.724$

31) A negative charge of -2.0×10^{-4} C and a positive charge of 8.0×10^{-4} C are separated by 0.30 m. What is the force between the two charges? [-1.6×10^4 N]

$q_1 = -2.0 \times 10^{-4}\,C$

$q_2 = 8.0 \times 10^{-4}\,C$

$d = 0.30\,m$

$F = ?$

$F = \frac{k q_1 q_2}{d^2}$

~~F = -2.0 × 10⁻⁴ C~~

$F = \frac{8.99 \times 10^9 (-2.0 \times 10^{-4})(8.0 \times 10^{-4})}{(0.30\,m)^2}$

$F = -15982.222\,N$

$F \approx -1.6 \times 10^4\,N$

32) If a current of 300.0 mA flows in a circuit for 25 s, how much charge has been transferred? [7.5 C]

$I = 300.0\,mA$
$= 300.0 \times 10^{-3}\,A$

$\Delta t = 25\,s$

$Q = ?$

$I = \frac{Q}{\Delta t}$

$Q = I \Delta t$

$Q = 300.0 \times 10^{-3}\,A\,(25\,s)$

$Q = 7.5\,C$

33) How much work is done by a 1.5 V cell that moves 5.4×10^{18} electrons along a wire? [1.3 J]

$W = ?$

$V = 1.5\,V$

$n = 5.4 \times 10^{18}$

$e = 1.602 \times 10^{-19}\,C$

$V = \frac{W}{q}$

$V = \frac{W}{ne}$

$Vne = W$

$W = 1.5\,V(5.4 \times 10^{18})(1.602 \times 10^{-19}\,C)$

$W = 1.29762\,J$

$W \approx 1.3\,J$

34) What is the electrical resistance of a 12-gauge copper wire, 152.4 m long, at room temperature? 12-guage wire has diameter of 2.053 mm and a resistivity of 1.72 x 10-8 Ωm. [0.792 Ω]

$R = ?$

$L = 152.4\,m$

$d = 2.053 \times 10^{-3}\,m$

$\rho = 1.72 \times 10^{-8}\,\Omega m$

$R = \frac{\rho L}{A}$

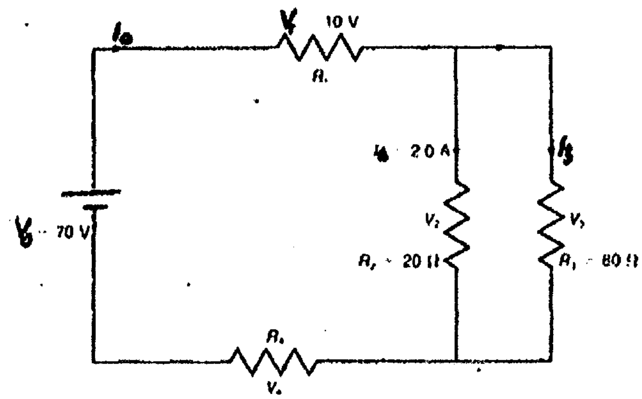
$R = \frac{\rho L}{\pi (\frac{d}{2})^2}$

$R = \frac{1.72 \times 10^{-8}\,\Omega m\,(152.4\,m)}{\pi \left(\frac{2.053 \times 10^{-3}\,m}{2}\right)^2}$

$R = 0.7918549462\,\Omega$

$R \approx 0.792\,\Omega$

35) Solve the following circuit:



	V	I	R
R_1	10V	2.5A	4Ω
R_2	40V	2.0A	20 Ω
R_3	40V	0.5A	80Ω
R_4	20V	2.5A	8Ω
Total	70V	2.5A	28Ω

36) Find the mass defect, expressed in kilograms, and the binding energy for a carbon-12 nucleus. [1.6429 x 10^{-28} kg, 1.476 x 10^{-11} J or 92.16 MeV]

$\Delta m = ?$

$E = ?$

$\Delta m = m_{nucleons} - m_{nucleus}$

$m_{nucleons} = 6m_p + 6m_n$

$= 6(1.007276u) + 6(1.008665u)$

$= 12.095646\,u$

$m_{nucleus} = m_{atom} - 6m_e$

$= 12u - 6(5.485799 \times 10^{-4}u)$

$= 11.99670852\,u$

$\Delta m = 12.095646u - 11.99670852\,u$

$\Delta m = 0.0989374794u$

$\Delta m \approx 1.642 \times 10^{-28}\,kg$

$E = \Delta m c^2$

$E = 1.642 \times 10^{-28}\,kg\,(3.00 \times 10^8\,m/s)^2$

$E = 1.478 \times 10^{-11}\,J$

or $E = 0.0989374794u\left(\frac{931.5\,MeV}{1u}\right)$

$E \approx 92.16\,MeV$

37) Calculate the energy released during α -decay of $^{230}_{90}Th$.   [7.641 x 10^-13 J]

$^{230}_{90}Th \rightarrow ^{226}_{88}Ra + ^{4}_{2}\alpha$

$230.033134u \rightarrow 226.0254u + 4.002603u$

$230.033134u \rightarrow 230.028013u$

$\Delta m = 5.121 \times 10^{-3} u$

$E = mc^2 = 5.121 \times 10^{-3} u \left(\frac{1.66 \times 10^{-27} kg}{u}\right)(3.00 \times 10^8 m/s)^2$

$E \approx 7.651 \times 10^{-13} J$

or $E = 5.121 \times 10^{-3} u \left(\frac{931.5 MeV}{u}\right)$

$E \approx 4.77 MeV$

38) A sample of 1.0 g of tritium is produced. What will be the mass of tritium remaining after 24.6 years? [0.25 g]

$N_0 = 1.0g$ = ~~0.001kg~~

$n = \frac{24.6 \text{ years}}{12.3 \text{ years}}$

$N = ?$

$N = N_0 \left(\frac{1}{2}\right)^n$

$N = 1.0g \left(\frac{1}{2}\right)^{\frac{24.6}{12.3}}$

$N = 0.25 g$